

Formerly Utilized MED/AEC Remedial Action Pro

**Radiological Survey of the Museum of Science and
57th Street and Lake Shore Drive, Chicago**

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**U.S. Department
Assistant Secretary
Division of Environmental Con
Washingt**

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This is one of a series of reports resulting from a program initiated in 1974 by the Atomic Energy Commission (AEC) for determination of the condition of sites formerly utilized by the Manhattan Engineer District (MED) and the AEC for work involving the handling of radioactive materials. Since the early 1940's, the control of over 100 sites that were no longer required for nuclear programs has been returned to private industry or the public for unrestricted use. A search of MED and AEC records indicated that for some of these sites documentation was insufficient to determine whether or not the decontamination work done at the time nuclear activities ceased is adequate by current guidelines.

This report contains the results of surveys of the current radiological condition of the Museum of Science and Industry, 57th Street and Lake Shore Chicago, Illinois. Findings of this survey indicate there is no identifiable radioactivity remaining at this facility from operations conducted by the MED or AEC during the period 1946 thru 1953.

This survey was performed by the following Health Physics personnel of the Occupational Health and Safety Division, Argonne National Laboratory, Argonne, Illinois: R. A. Wynveen, W. H. Smith, C. J. Mayes, P. C. Gray, D. W. Reilly

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INTRODUCTION

During the Manhattan Engineer District/Atomic Energy Commission (MED/AEC) Argonne National Laboratory (ANL) occupied space at the Museum of Science and Industry, Chicago, Illinois. From August 15, 1946 until July 1, 1949, ANL occupied 36,000 square feet on the ground, first, and balcony floors of the East Pavilion. From August 15, 1946 until July 15, 1953, ANL also occupied 16,000 square feet in the 2nd Balcony of the West Court. The actual use of the facility is unknown. Although most of the area was believed to be occupied as office space, some handling of radioactive materials was known to have taken place. The nature and activity of these materials is unknown.

Personnel involved with the facility during ANL's occupation recalled at least one spill of radioactive material near the service elevator on the ground floor of the East Pavilion and its subsequent decontamination.

Due to the uncertainty of the use of the facility, a radiation survey of the entire area was undertaken from January 11, 1977 until April 13, 1977. This survey was performed on an intermittent basis to minimize the disturbance of the Museum's daily operations. The purpose of this survey was to determine if any detectable contamination remains as a result of the MED/AEC operation.

Part of the ground and main floors of the East Pavilion are presently occupied by the University of Chicago for storage and office space or are used for support of the Museum's operations. The 2nd Balcony of the West Court is now occupied by the Museum of Science and Industry and the Academy of Interdisciplinary Methodology.

General

All accessible original walls were surveyed to a height of seven feet and all accessible floor areas were surveyed. In many areas, the floors and walls had been retiled or painted. Even though these were not the original surfaces, these areas were surveyed since the capability of detection was adequate to detect activity on the original structures underneath. A representative selective survey of overheads such as pipes, vents and light fixtures was performed in areas where the original structures were available. The roof of the East Pavilion was also surveyed. See Table 1 and Figure 1 for locations of accessible areas surveyed.

Instrumentation

Three types of survey instruments were used (Table 2). An Eberline FM-300 having a detection area of 325 square centimeters (cm^2), utilizing the Eberline PAC-4G-3 electronics, was used to survey the floors. A PAC-4G-3 with a hand-held detector, 61cm^2 in area, was used to survey the walls and other accessible areas. Double aluminized mylar [- 0.85 milligrams per square centimeter (mg/cm^2)] was used in both detectors. This allows for low energy detection and greater instrument sensitivity. Both of these instruments were initially used in the beta mode. In this mode, the detector responds to a wide energy range of electromagnetic and particulate radiations. When areas were found which indicated a higher count rate than the average instrument background, the instrument was then switched to the alpha mode and a reading of the alpha activity was obtained.

An End Window Geiger-Mueller (G-M) Detector, Eberline Model E-500B with a special 7/8 inch diameter window held three feet above the floor, was used to determine general background radiation levels throughout the surveyed area. If an area was found that had an elevated count rate, a contact reading was obtained.

um-226 (^{226}Ra) calibration source. The PAC-4G-3 instruments were calibrated in the alpha mode using a flat plate infinitely thin Plutonium-239 (^{239}Pu) and in the beta mode with a flat plate infinitely thin Strontium-90-Yttrium-90 (^{90}Sr - ^{90}Y) standard. The instruments were calibrated to an apparent efficiency.

It must be realized that the numerous isotopes that could be encountered exhibit emission energies differing from that of ^{239}Pu and ^{90}Sr - ^{90}Y utilized for calibration. When detecting known isotopes that emit alpha and beta particles differing from that of the standards, a conversion factor is developed to determine the appropriate yield.

Surveys

Surveys were taken throughout the East Pavilion and West Balcony areas of the building. Only original structures and components such as walls, floors, pipes, etc. were smeared. All smears were taken with No. 1 Whatman filter paper, 4 inches (10.16 cm) in diameter. Smears of one square foot were normally taken.

If an area was found which had a higher than normal background, a smear of 100 cm² was taken.

A smear of 100 cm² was also taken if an area indicated excessive dirt. All smears were counted in groups of ten using the 10-Wire Flat Plate Gas

Proportional Detector, developed at ANL, utilizing an Eberline Mini Scaler Model 1000.

One smear of each group was removed and counted in a Nuclear Measurements Corporation Proportional Counter - 3A (PC-3A) 2 π Internal Gas Flow Counter using a 1/2 inch spun top. This procedure was used as an additional means of checking the results of the 10-Wire Flat Plate Gas Proportional Counter.

In addition, any smears indicating elevated amounts in the 10-Wire Flat Plate Gas Proportional Counter, were also counted in the more sensitive PC-3A counter. Smears were counted in both detectors for alpha and beta activity. Appendix 1 includes the calibration and smear count conversion factors used.

... of the smears. A number, n, indicates the location
that smear in the room. A number, (n), indicates a smear of an overhead
structure. A number [n], indicates an elevated direct reading.

Air Samples

Air samples were collected using a Filter Queen air sampling device.
Air samples were taken at a flow rate of 15 cubic meters per hour (M^3/hr)
0cm² sheet of Hollingsworth-Vose (HV-70-9 mil) filter media which collected
the particulates present in the air. A 10% portion, 5cm in diameter, was
from the filter media and counted in the NMC PC-3A 2 π Internal Gas Flow Co
utilizing a mylar spun top for both alpha and beta activity. Sampling res
are used to determine radon concentrations and the presence of any long-l
activity. Air sample data is presented in Appendix 2.

Soil Samples

In addition to the survey inside the building, soil corings were taken
selected locations outside the East Pavilion of the Museum to determine the
composition, if any, of isotopes that could have been spilled or released fr
t Pavilion. Radiochemical (fluorometric) and gamma spectrum analysis we
ducted on these soil samples.

The corings were effected using a four (4) inch in diameter by six (6)
length right circular cylinder; commonly called a hole cutter. This devi
ormally used for cutting holes for the cups in golf courses.

Each core was 1 foot in length and divided into four (4) segments. Sta
the surface, three (3) separate two (2) inch segments are cut, bagged,
ed A, B and C respectively; the final segment a six (6) inch section was
ed D.

t migration has occurred, to reduce the dilution of lower level soil with
er level segments in respect to the surface deposition of the contaminants
e versa, and to reveal any overburden or back fill that may have occurred
r the years.

Three soil samples were taken from the grounds adjacent to the East Pavil
the Museum. Figure 1F indicates the soil sample locations.

Background data for the soil sample analysis (Table 8) were obtained
umber of soil samples taken from the Chicago area. This information was
ained from the Environmental Monitoring Section of the Occupational Health
ety (OHS) Division of ANL.

All soil samples were processed at ANL (Figure 3) and shipped to a comm
oratory (LFE Environmental Analysis Laboratories) for radiochemical
uorometric) and gamma spectrum analysis. Their soil analysis procedure is
ibed in Table 6,

Sample preparation consisted of weighing the samples in their entirety a
n drying for approximately 24 hours at 80° Centigrade. All samples were t
weighed, put into mill jars (2.3 gallon) and milled until a sufficient amou
the soil sample would pass a No. 30 standard sieve. At no point were the
heavy material ground or pulverized since this material would act as a di
hence lower the concentration per unit volume of deposited material.

After sufficient milling, the material was sieved using a No. 30, 600 mi
standard stainless sieve. The rocks and dross vs. sieved material (< 600
segregated, bagged, and weighed separately. Soil sample weights are give
Table 5.

radiochemical (fluorometric) only. Every effort was made throughout preparation operations to reduce or eliminate cross contamination. Samples which were suspected of containing elevated amounts of radioactivity were processed in equipment separate from the soil samples considered to be at ground levels. All items of equipment were scrubbed and air dried prior to introduction of the next sample.

ANALYSIS OF SURVEY RESULTS

General

All data, including diagrams of survey locations, are attached to this report. This section discusses the results of the survey and the findings therefrom. Instrument readings and smear results were normalized to units of disintegrations per minute per one hundred square centimeters (dpm/100cm²). (See Appendix A for the conversion factors used.) All data is reported in net counts. Background counts have been subtracted from the gross counts prior to normalization to counts per minute per one hundred square centimeters (cpm/100cm² or dpm/100cm²). The beta mode readings are compensated for any alpha contamination. The room background levels varied somewhat due to the construction materials used in them. Table 3 provides an average background reading for all modes of operation for the different instruments used.

The areas accessible for survey varied from room to room. Areas accessible for survey are presented in Table 1. The average percent of the total area surveyed was 50% for the floors and 40% for the walls.

ould be detected except in the following four rooms.

Room G-340 - This room is a small instrument shop where a marked Cobalt-60 (^{60}Co) source was found in the cabinet. A direct reading with an End Window Detector was 80 milliRoentgens per hour (mR/hr) at contact. When the detector was held three feet away from the source in its shielded container, no radiation above background levels, < 0.03 mR/hr, could be detected.

Room E-201 and Restrooms on 2nd Balcony - These washrooms contained a tile on the floors. This tile was also noted in other restrooms of the Museum. These tiles indicated 8.1×10^3 dpm/100cm² Potassium-40 (^{40}K) with the PAC-1 in the beta mode. No alpha activity was detected. No radiation above background levels could be found from the tile using the End Window G-M Detector. No alpha activity was detected from floor tile smears. It was determined from a gamma spectral analysis that the tile contained elevated amounts of (^{40}K) which would cause an elevated reading. (See Figure 2 for gamma emission spectra.) Annual general background readings taken at three feet above the floor level were less than 0.03 mR/hr.

Air Surveys

No contamination above background levels was detected on any smears.

Air Samples

The air sampling results are presented in Table 4. The variation of the results do not appear to be a result of any MED/AEC operation, but rather the variation reflects the differences in the construction materials used throughout the facility. Other factors such as the ventilation of the room can cause the concentrations to vary. All radon concentrations determined are below the maximum permissible concentrations (MPC) for an uncontrolled area as listed in the "Standard for Protection Against Radiation," Code of Federal Regulations, Title 10, Part

Samples

Results submitted by LFE Environmental Analysis Laboratories, as listed in Table 7, are reported in picocuries per gram (pCi/g) for the Germanium (Lithium) [Li] spectral analysis and in micrograms per gram ($\mu\text{g/g}$) for the uranium gravimetric analysis. The latter concentrations were converted to pCi/g by means of the example calculation as shown in Appendix 3.

The background data is presented in Table 8. The background samples indicate natural uranium concentrations ranging from 0.03 to 2.0 pCi/g. Results of soil samples taken at the Museum of Science and Industry indicate a general normal background concentration in the soil.

FINDINGS

The survey results show that no radioactive contamination above background was detected throughout the areas used for MED/AEC activities. However, a small ^{60}Co source which was used as a static eliminator was found in Room C-340. The floor tiles which were used in the restrooms, showed elevated levels of naturally occurring ^{40}K . Neither of these are a result of any MED/AEC operations. The results of the soil sample analysis shows no elevated readings above the natural background level is present in the soil from this region.

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Room or Area No.	Percent of Area Accessible for Survey		Air Sample (pCi/l)	Beta Mode (1) Direct Readings (dpm/100cm ²)				Alpha Mode Direct Readings (dpm/100cm ²)				End Window (mR/hr) Contact 3 feet	Smear Results (dpm/100cm ²)
	Floor	Wall		Floors	Walls	Overhead	Other	Floors	Walls	Overhead	Other		
E-1	70	20	NS(2)	BKGD(3)	BKGD	OSU(4)	BKGD	NA(6)	NA	NA	NA	NN(7)	BKGD
E-2	80	25	1.25	BKGD	BKGD	OSU	NE(5)	NA	NA	NA	NA	NN	BKGD
E-3	70	20	NS	BKGD	BKGD	OSU	BKGD	NA	NA	NA	NA	NN	BKGD
E-4	60	25	NS	BKGD	BKGD	OSU	BKGD	NA	NA	NA	NA	NN	BKGD
E-4A	40	25	NS	BKGD	BKGD	OSU	NE	NA	NA	NA	NA	NN	BKGD
E-4AA	40	30	NS	BKGD	BKGD	OSU	BKGD	NA	NA	NA	NA	NN	BKGD
E-7	95	30	NS	BKGD	BKGD	BKGD	NE	NA	NA	NA	NA	NN	BKGD
E-8	40	40	NS	BKGD	BKGD	BKGD	NE	NA	NA	NA	NA	NN	BKGD
E-9	50	50	NS	BKGD	BKGD	BKGD	NE	NA	NA	NA	NA	NN	BKGD
E-11	50	50	NS	BKGD	BKGD	BKGD	NE	NA	NA	NA	NA	NN	BKGD
E-12	40	40	NS	BKGD	BKGD	OSU	NE	NA	NA	NA	NA	NN	BKGD
E-14	60	50	0.48	BKGD	BKGD	BKGD	NE	NA	NA	NA	NA	NN	BKGD
E-15	20	10	0.48	BKGD	BKGD	BKGD	NE	NA	NA	NA	NA	NN	BKGD
E-16	20	20	NS	BKGD	BKGD	BKGD	NE	NA	NA	NA	NA	NN	BKGD
E-17	50	50	NS	BKGD	BKGD	BKGD	BKGD	NA	NA	NA	NA	NN	BKGD
E-18	30	20	1.5	BKGD	BKGD	BKGD	NE	NA	NA	NA	NA	NN	BKGD
E-19	20	20	NS	BKGD	BKGD	BKGD	NE	NA	NA	NA	NA	NN	BKGD

(1) Beta Mode detects both electromagnetic and particulate radiation.

(2) NS - (Not Selected) Air sample locations were chosen on a selected basis throughout the areas surveyed.

(3) BKGD (Background) Instrument Background Readings

Beta Mode 1500-2000 cpm/325cm² 0-50 cpm/325cm²
Alpha Mode
Floor Monitor

(4) OSU (Overhead Structure Unavailable) Floor and wall survey necessity to demolish existing structures to reach original structure.
(5) NE (Non-Existant) This location did not contain structure as "Other" such as the following: ducts, louvers, pipes, etc.
(6) NA (Not Applicable) No activity detected above background therefore, no alpha mode survey was necessary.
(7) NN (Not Necessary) No activity was detected; therefore, no alpha mode survey was necessary.

DATA SHEETS SHOWING ROOM SURVEY RESULTS

Room or Area No.	Percent of Area Accessible for Survey Floor	Air Sample (pCi/k)	Beta Mode (1) (dpm/100cm ²)		Direct Readings (dpm/100cm ²)		Alpha Mode Direct Readings (dpm/100cm ²)		End Window (mR/hr) Contact 3 feet	Smear Results (dpm/100cm ²)	Comments
			Floors	Walls	Floors	Walls	Floors	Walls			
-20	80	NS (2)	BKGD (3)	BKGD	OSU (4)	BKGD	NA (6)	NA	NN (7)	BKGD	
-21S	5	NS	BKGD	BKGD	BKGD	NE (5)	NA	NA	NN	BKGD	
-21N	20	NS	BKGD	BKGD	BKGD	BKGD	NA	NA	NN	BKGD	
airwell f E-14	90	NS	BKGD	BKGD	OSU	NE	NA	NA	NN	BKGD	
100	40	NS	BKGD	BKGD	OSU	NE	NA	NA	NN	BKGD	
101	30	NS	BKGD	BKGD	OSU	NE	NA	NA	NN	BKGD	
102	70	NS	BKGD	BKGD	OSU	NE	NA	NA	NN	BKGD	
103	50	NS	BKGD	BKGD	OSU	BKGD	NA	NA	NN	BKGD	
104	40	NS	BKGD	BKGD	OSU	NE	NA	NA	NN	BKGD	
105	30	NS	BKGD	BKGD	OSU	NE	NA	NA	NN	BKGD	
105B	30	NS	BKGD	BKGD	OSU	NE	NA	NA	NN	BKGD	
106	40	NS	BKGD	BKGD	OSU	NE	NA	NA	NN	BKGD	
108	50	NS	BKGD	BKGD	BKGD	BKGD	NA	NA	NN	BKGD	
109	30	NS	BKGD	BKGD	OSU	NE	NA	NA	NN	BKGD	
110	40	NS	BKGD	BKGD	OSU	NE	NA	NA	NN	BKGD	
112											
114											
117N	75	0.49	BKGD	BKGD	OSU	NE	NA	NA	NN	BKGD	

(1) Beta Mode detects both electromagnetic and particulate radiation

(2) NS-(Not Selected) Air sample locations were chosen on a selected basis throughout the area surveyed.

(3) BKGD (Background) Instrument Background Readings.

Beta Mode

1500-2000 cpm/325cm²

Floor Monitor

150-200 cpm/61cm²

PAC-46-3

(4) OSU (Overhead Structure Unavailable) Floor and wall survey indicate necessity to demolish existing structures to reach original overhead.

(5) NE (Non-Existant) This location did not contain structural items as "other" such as the following: ducts, louvers, pipes and vents.

(6) NA (Not Applicable) No activity detected above background in the therefore, no alpha mode survey was necessary.

(7) NN (Not Necessary) No activity was detected; therefore, no contact

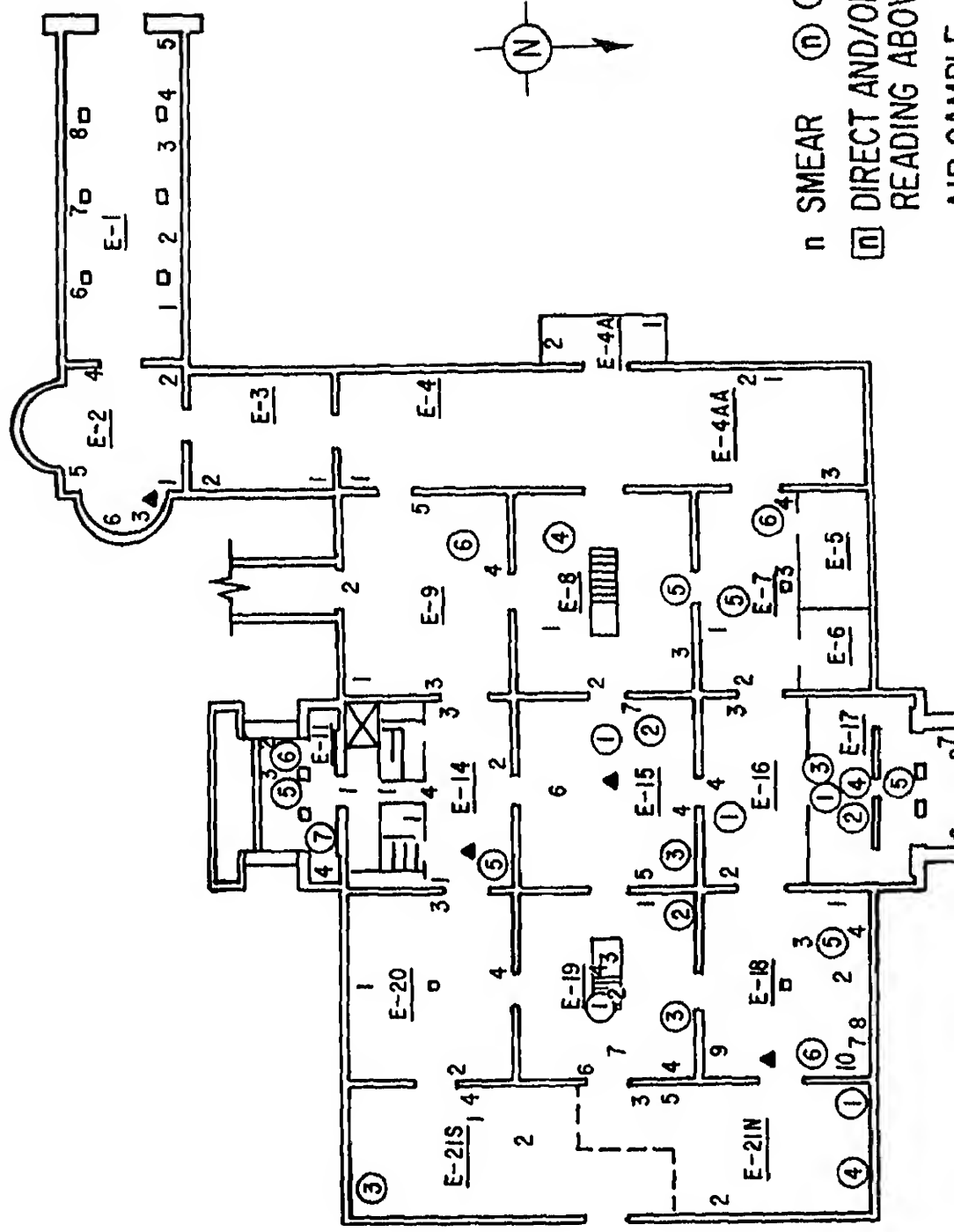
TABLE I
DATA SHEETS SHOWING ROOM SURVEY RESULTS

Room or Area No.	Percent of Area Accessible for Survey		Air Sample (pCi/l)	Beta Mode (1) Direct Readings (dpm/100cm ²)		Alpha Mode Direct Readings (dpm/100cm ²)		End Window Contact 3 feet	Smear Results (dpm/100cm ²)	Comments
	Floor	Wall		Floors	Walls	Overhead	Other			
C-343	15	15	NS ⁽²⁾	BKGD ⁽³⁾	BKGD	OSU ⁽⁴⁾	BKGD	NA ⁽⁶⁾	NA	NA
C-244A								NN ⁽⁷⁾	BKGD	
C-345										
346, 347										
48, 349,										
54, 355,	30	20	NS	BKGD	BKGD	BKGD	BKGD	NA	NA	BKGD
56, 357										
58										
nd Floor	100	50	NS	BKGD	BKGD	OSU	BKGD	NA	NA	BKGD
alcony										
est Hall										
nd Floor	100	50	0.31	BKGD	BKGD	OSU	NE ⁽⁵⁾	NA	NA	BKGD
alcony										
orth Hall										
C-359	15	20	NS	BKGD	BKGD	BKGD	NE	NA	NA	BKGD
C-360	30	40	NS	BKGD	BKGD	OSU	BKGD	NA	NA	BKGD
C-361	30	40	NS	BKGD	BKGD	OSU	BKGD	NA	NA	BKGD
C-362	30	40	NS	BKGD	BKGD	OSU	BKGD	NA	NA	BKGD
C-363	30	40	NS	BKGD	BKGD	OSU	BKGD	NA	NA	BKGD
C-364	30	40	NS	BKGD	BKGD	OSU	BKGD	NA	NA	BKGD
C-365	30	40	NS	BKGD	BKGD	OSU	BKGD	NA	NA	BKGD
C-366										
C-367	30	40	NS	BKGD	BKGD	OSU	BKGD	NA	NA	BKGD
Roof	100	100	NS	BKGD	BKGD	OSU	BKGD	NA	NA	BKGD

(1) Beta Mode detects both electromagnetic and particulate radiation.

(4) OSU (Overhead Structure Unavailable) Floor and wall survey in

SURVEY LOCATIONS OF EAST PAVILION - GROUND FLOOR



SURVEY LOCATIONS OF EAST PAVILION - FIRST FLOOR

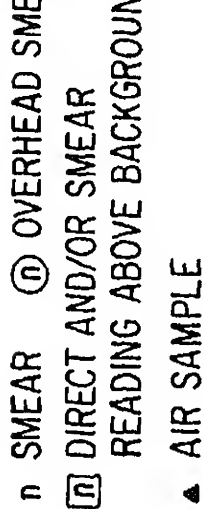


FIGURE 1C

SURVEY LOCATIONS OF EAST PAVILION - FIRST BALCONY

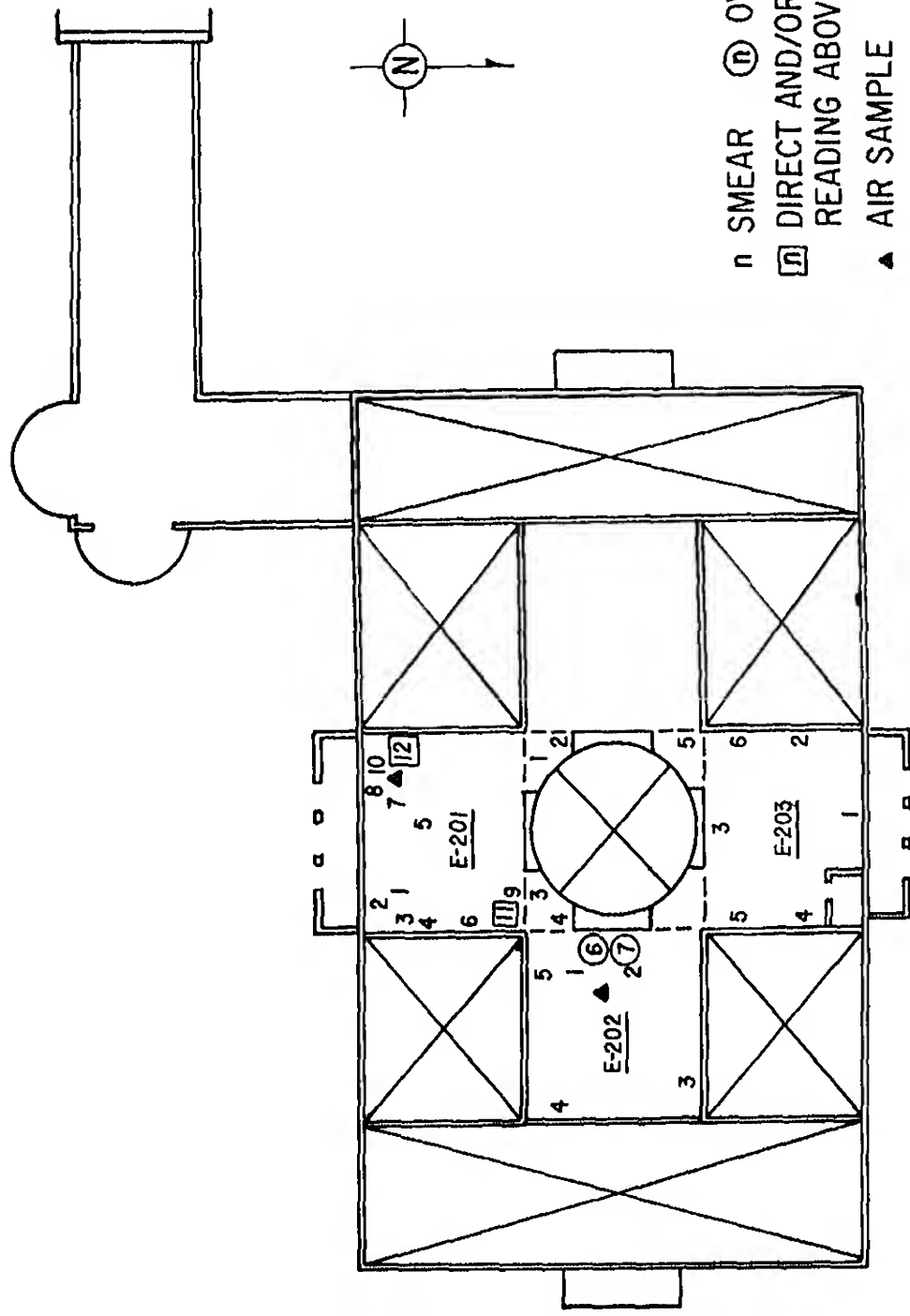
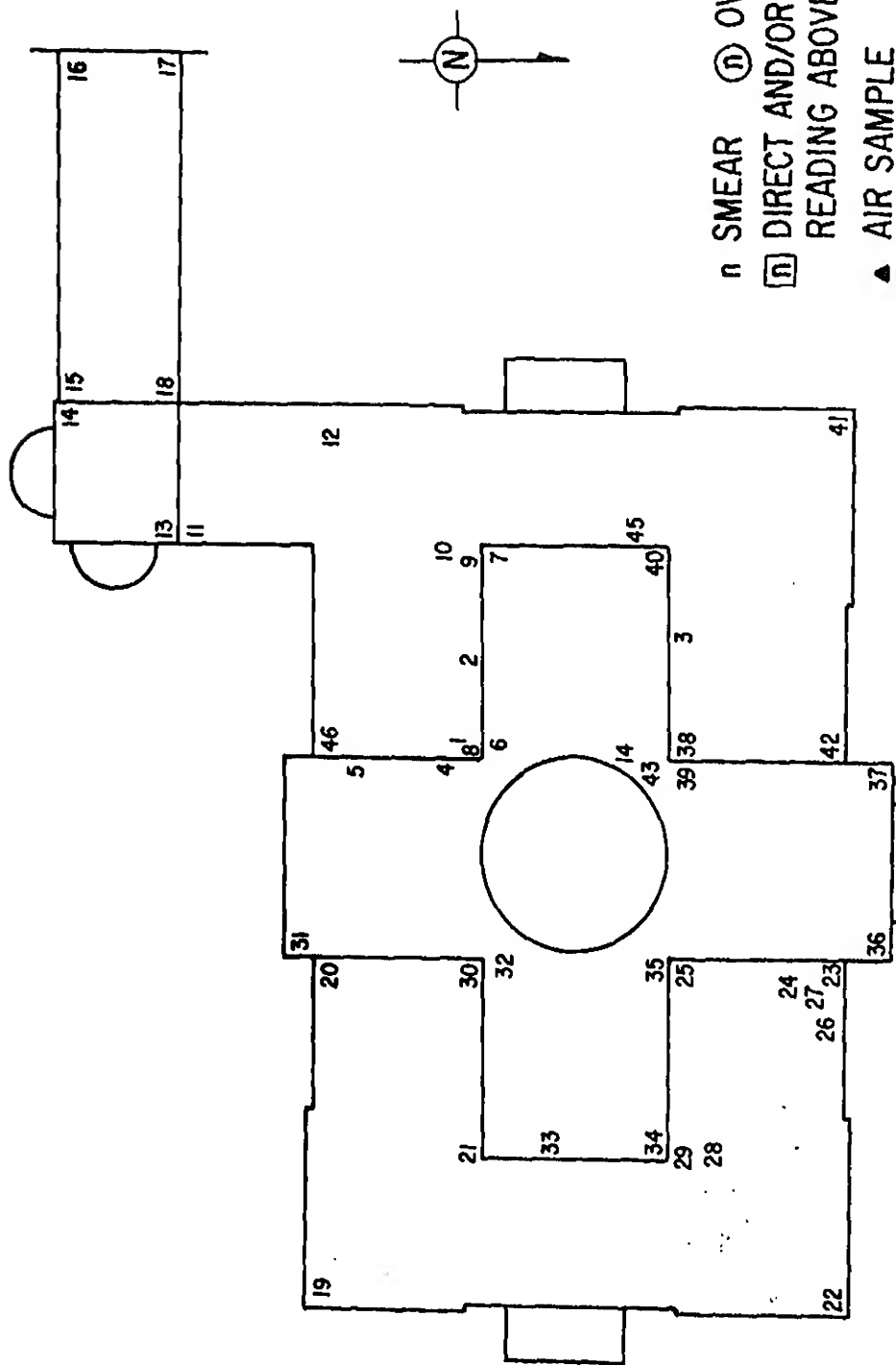
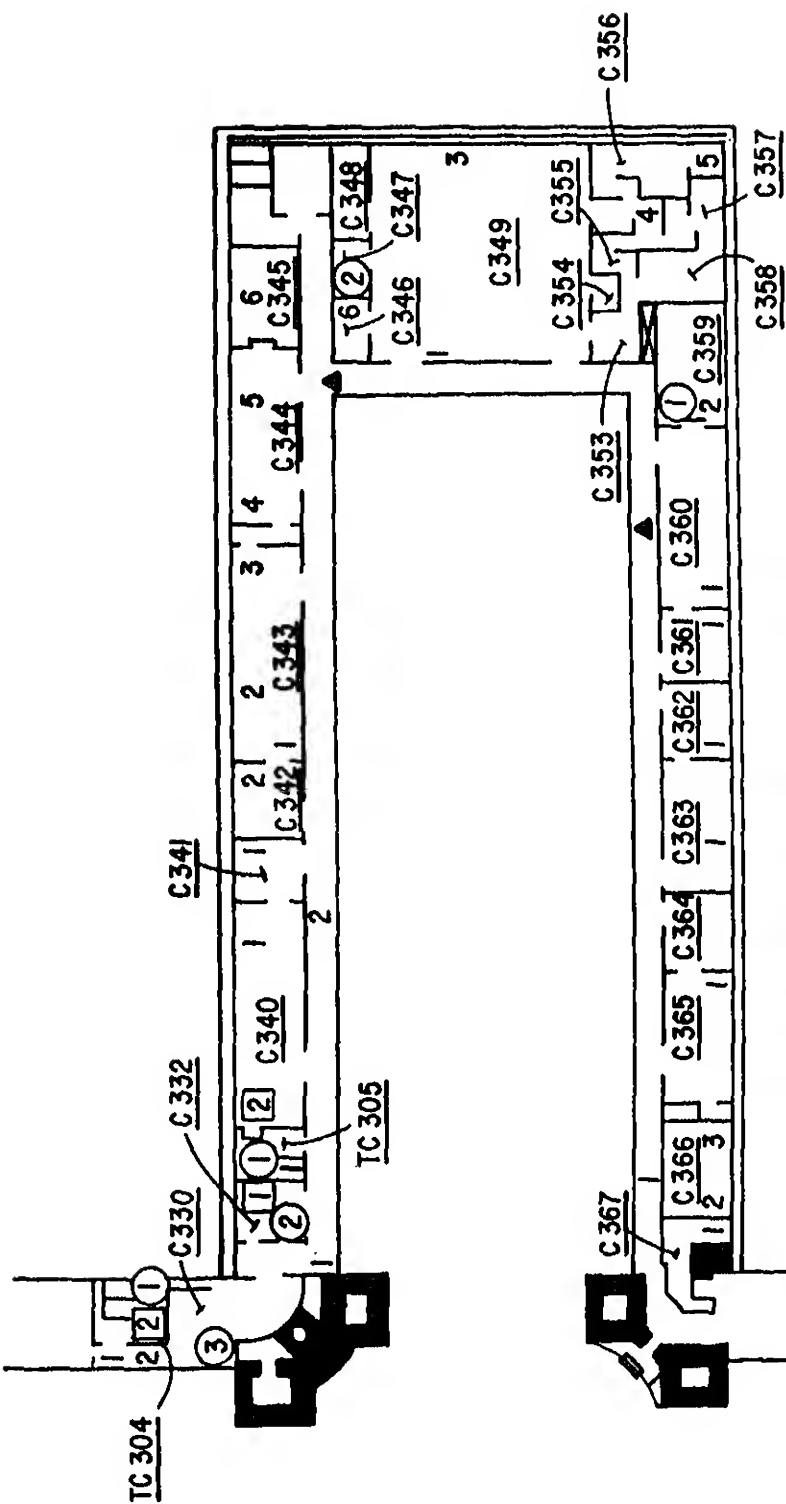


FIGURE 1D

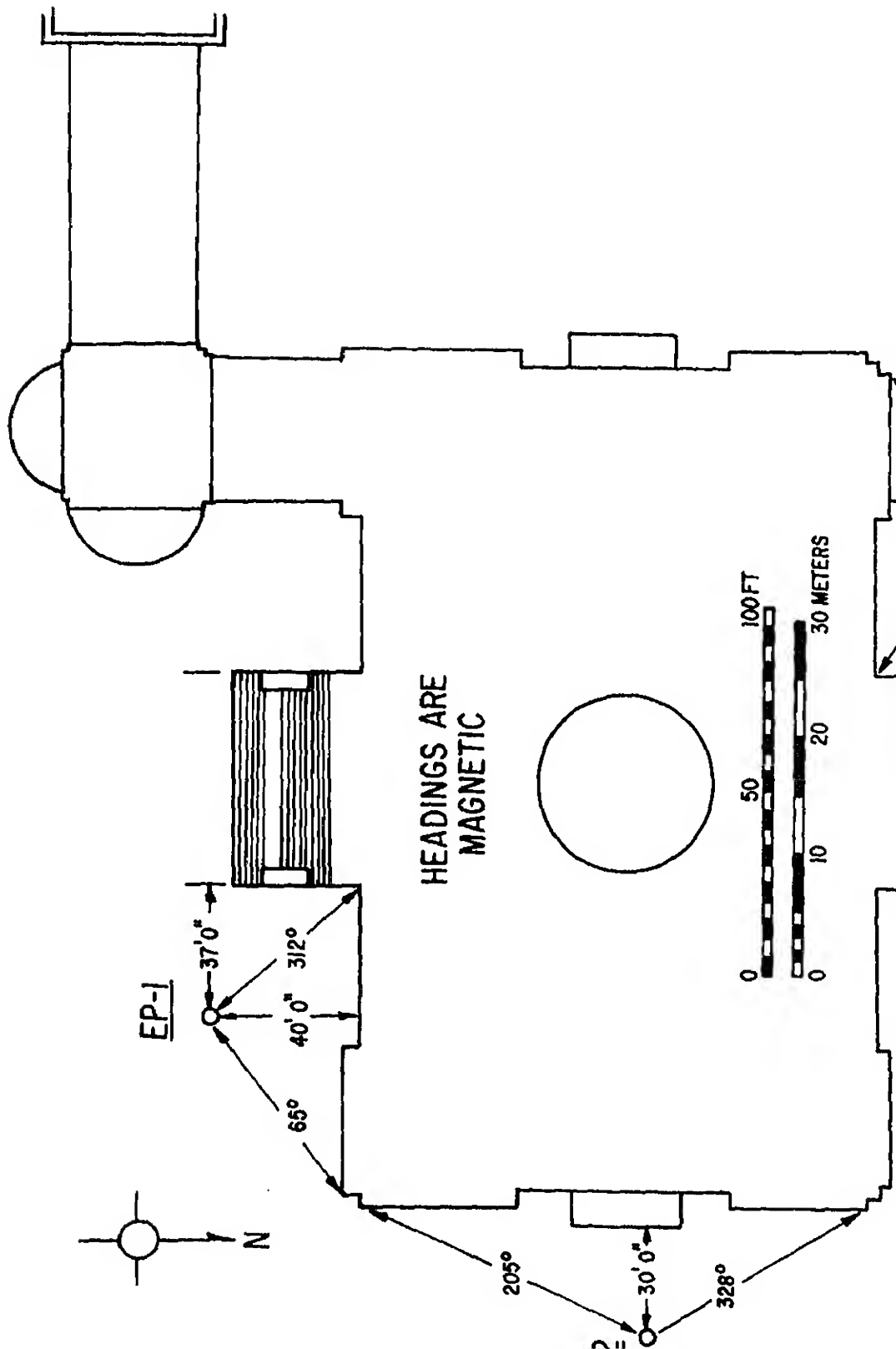
SURVEY LOCATIONS OF EAST PAVILION - ROOF





n SMEAR (n) OVERHEAD SM
 [n] DIRECT AND/OR SMEAR
 READING ABOVE BACKGROU
 ▲ AIR SAMPLE

SURVEY LOCATIONS OF SOIL SAMPLES



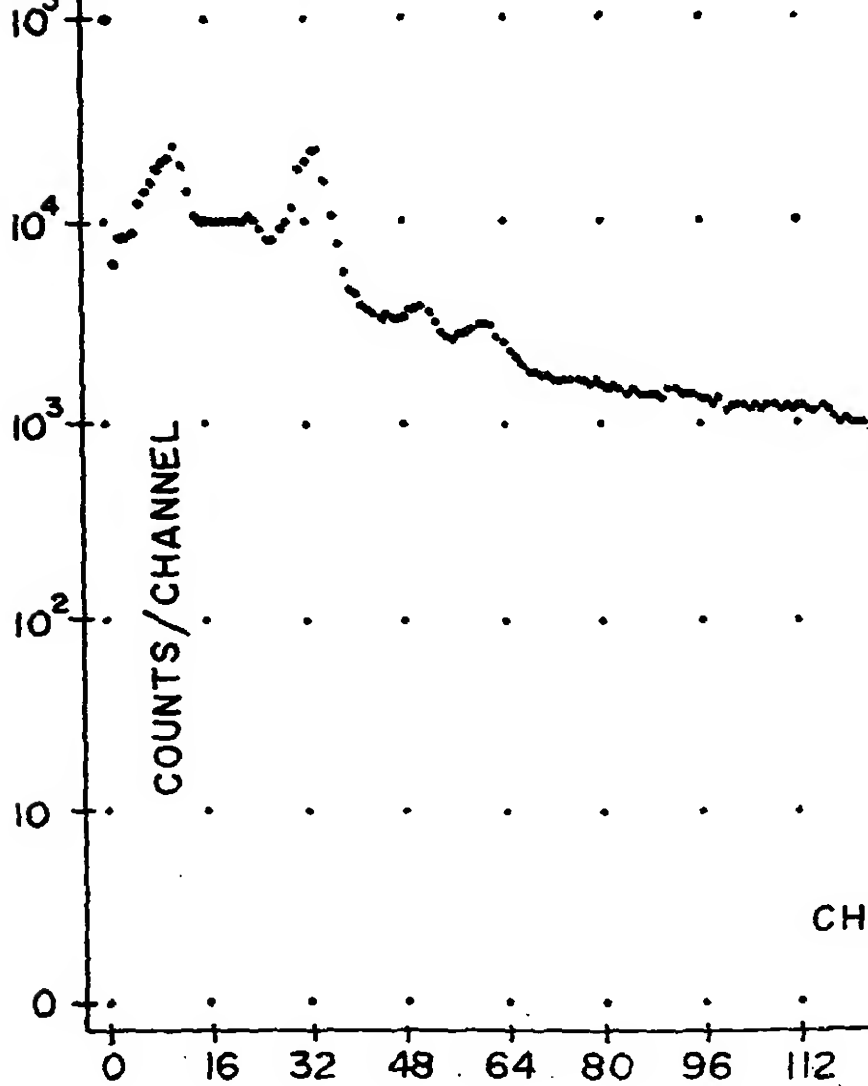
INSTRUMENTATION USED IN SURVEY

<u>Type</u>	<u>Inventory Number</u>	<u>Probe Area</u>	<u>Window</u>
Eberline Floor Monitor FM-4G utilizing a PAC-4G-3	181501	325cm ²	0.85mg/cm ²
Eberline Floor Monitor FM-4G utilizing a PAC-4G-3	181581	325cm ²	"
PAC-4G-3	165251	61cm ²	"
"	165252	"	"
"	165255	"	"
"	165256	"	"
"	183413	"	"
"	183414	"	"
Eberline HP-90 Beta-Gamma End Window	159006	-	1.4 - 2m
Nuclear Measurement Corporation PC-3A-2 π Internal Gas Flow Counter	114969	-	0.85mg/cm ²
Argonne National Laboratory Filter Queen Air Sampler using HV-70 filter media	-	-	-
Argonne National Laboratory 10 Wire Flat Plate Gas Proportional Detector with Eberline Mini Scaler MS-2	184343	-	0.85mg/cm ²

INSTRUMENT BACKGROUND READINGS

<u>Instrument</u>	<u>Readings *</u>	
	<u>Alpha Mode (cpm)</u>	<u>Beta Mode (cpm)</u>
Eberline Floor Monitor FM-4G using <u>PAC-4G-3</u>		
#181501	0 - 50	1500 - 2000
#181581	0 - 50	1500 - 2000
<u>PAC-4G-3</u>		
#165251	0 - 50	150 - 200
#165252	"	"
#165255	"	"
#165256	"	"
#183413	"	"
#183414	"	"
Eberline HP-90 Beta-Gamma End Window		
Nuclear Measurement Corporation PC-3A-2" Internal Gas Flow Counter	0.4	50
Argonne National Laboratory 10 Wire Flat Plate Gas Proportional Detector with Eberline Mini Scaler MS-2	10	500

*Background readings were initially taken in the mobile laboratory and throughout the various areas inside the Museum of Science and Industry surveying.



RADON CONCENTRATION DETERMINATIONS

<u>Location</u>	<u>dpm/M³</u>	<u>pCi/l</u>	<u>% of MPC*</u>
E-2	2744	1.25	42
E-14	1057	0.48	16
E-15	1057	0.48	16
E-18	3372	1.5	51
E-114	1075	0.49	16
E-117	1567	0.71	24
E-201	2277	1.04	35
E-202	1476	0.67	22
South Hall (2nd Balcony West Court)	683	0.31	10
North Hall (2nd Balcony West Court)	671	0.31	10

*The 10CFR20 MPC for Radon-222 (²²²Rn) in an uncontrolled area is 3×10^{-9} μ Ci/cc which equals 3 pCi/l.

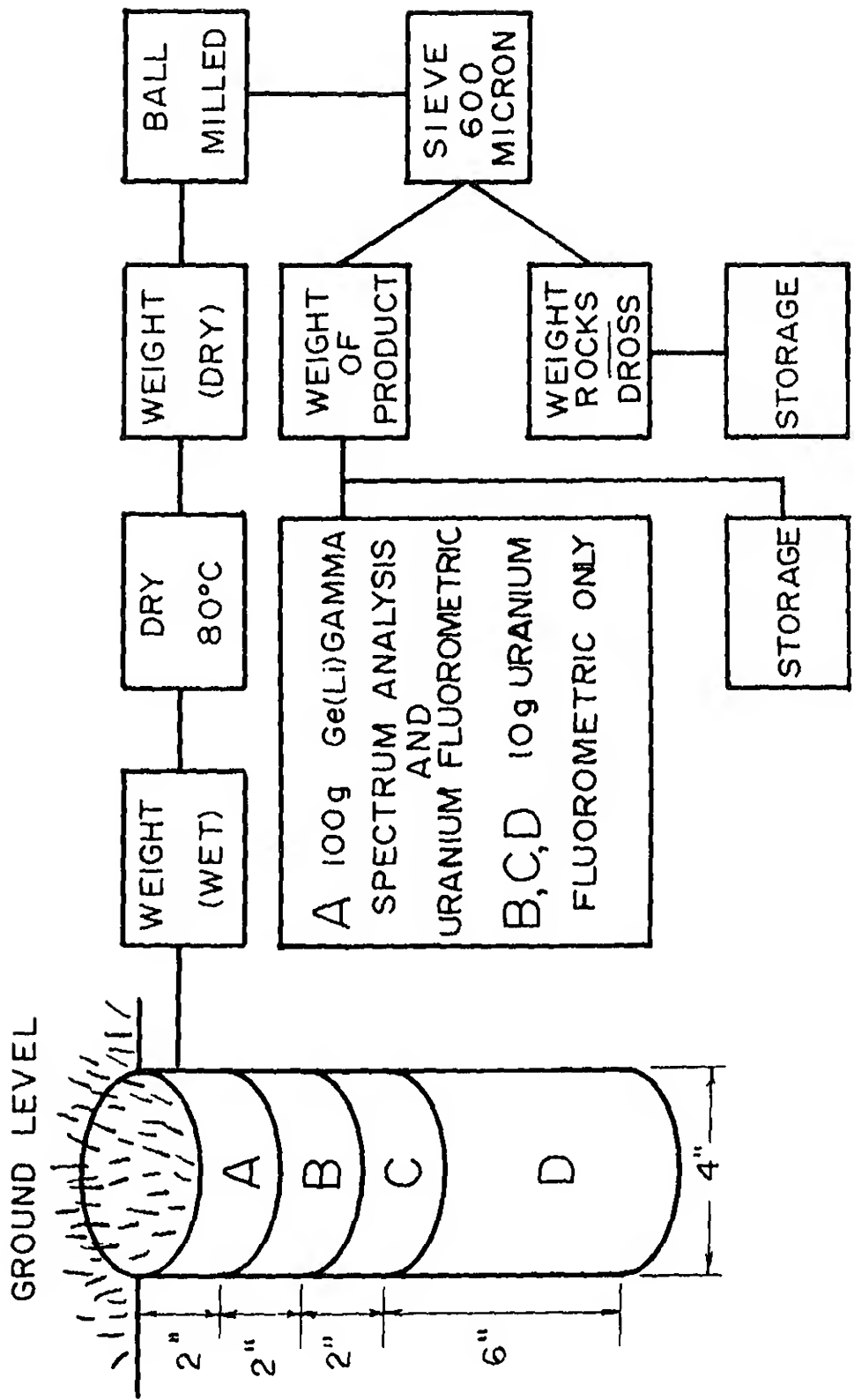
Example Calculation Room E-15

$$1057 \text{ dpm/M}^3 \times \frac{1 \text{ pCi}}{2.22 \text{ dpm}} \times \frac{\text{M}^3}{10^3 \text{ l}} = 0.48 \text{ pCi/l}$$

FIGURE 3

SOIL SAMPLING PROCEDURE AND PROCESSING DIAGRAM

ANL-HP-DWG. 78-2



SOIL SAMPLE WEIGHTS

Sample No.	Net Weight (grams)	Dry Weight (grams)	Sieved Weight (grams)	Rocks and Weight (grams)
P-1A	887.8	688.9	666.0	145.0
P-1B	749.0	582.0	551.6	3.5
P-1C	740.8	579.6	557.2	13.5
P-1D	1642.2	1281.8	1161.8	94.3
P-2A	616.1	435.2	376.0	55.3
P-2B	764.8	593.5	541.1	44.7
P-2C	1050.0	833.0	766.4	60.0
P-2D	2375.3	1944.5	1750.0	189.7
P-3A	677.8	495.9	417.1	72.2
P-3B	907.2	717.2	649.3	65.3
P-3C	962.3	785.5	750.4	26.9
P-3D	2142.2	1800.5	1563.3	222.9

LF-1 SOIL ANALYSIS PROCEDURE FOR TOTAL URANIUM AND GAMMA-EMITTING NUCLIDESSummary of Methods

A 60 milliliter (ml) volume of the received soil was counted in a petri dish for 500 minutes on a Ge(Li) detector over the energy range 0 - 1.5 MeV. This corresponded to between 60 to 100g of soil, depending upon bulk soil density. All distinctive photopeaks above instrument background were converted to dpm using a detector efficiency curve based upon a National Bureau of Standards Multi Gamma standard. The natural Thorium-232 (^{232}Th) and ^{226}Ra decay chains were calculated using the 0.910 MeV Actinium-228 (^{228}Ac) and 0.609 MeV Bismuth-214 (^{214}Bi) photopeaks respectively. Cesium-137 is reported for each sample as a representative gamma emitter. Potassium-40 (^{40}K) was observed on all soil samples, as indicated, but was not calculated or reported.

One gram of the soil sample was ashed and dissolved in HF-HNO₃ for the total uranium analysis. A 100-μ aliquot of the dissolved sample was fused with 98% LiF and the fluorescence determined using a Jarrell-Ash fluorometer. A quenching factor was determined for each sample by using an internal spike.

Ge(Li) SPECTRUM AND URANIUM FLUOROMETRIC ANALYSES RESULTS

Sample No.	Ge(Li) Spectra pCi/g received wt \pm σ (1)			U $\mu\text{g/g} \pm \sigma$
	^{137}Cs	^{232}Th Decay Chain	^{226}Ra Decay Chain	
EP-1A	1.43 ± 0.07	0.8 ± 0.2	0.75 ± 0.08	3.5 ± 0.4
EP-1B				2.6 ± 0.4
EP-1C				1.3 ± 0.4
EP-1D				3.1 ± 0.4
EP-2A	0.98 ± 0.05	0.9 ± 0.1	0.83 ± 0.07	2.2 ± 0.4
EP-2B				2.2 ± 0.5
EP-2C				1.9 ± 0.6
EP-2D				1.9 ± 0.4
EP-3A	1.05 ± 0.06	0.6 ± 0.2	0.93 ± 0.09	2.6 ± 0.4
EP-3B				3.5 ± 0.5
EP-3C				4.1 ± 0.5
EP-3D				2.4 ± 0.4
LFE Blank	0 ± 0.06	0 ± 0.1	0 ± 0.06	0 ± 0.2

- (1) One standard deviation due to counting statistics.
- (2) Data Results from LFE.
- (3) ANL Conversion from Appendix 3.

BACKGROUND SOIL SAMPLE DATA*

Cesium-137, Thorium, and Uranium in Soil 1976
concentrations in pCi/g

Date Collected	Location	Cesium-137	Thorium-232	Ur
July 22	Argonne Area	0.3 ± 0.1	0.21 ± 0.04	1
July 22	Argonne Area	0.1 ± 0.1	0.49 ± 0.04	2
July 22	Argonne Area	0.3 ± 0.1	0.48 ± 0.04	1
October 18	Argonne Area	0.1 ± 0.1	0.65 ± 0.07	1
October 18	Argonne Area	0.3 ± 0.1	0.43 ± 0.04	1
October 18	Argonne Area	0.4 ± 0.1	0.39 ± 0.04	1
	Average	0.2 ± 0.1	0.44 ± 0.14	1
<u>Off-Site</u>				
June 22	McKinley Woods State Park, IL	0.4 ± 0.1	0.16 ± 0.02	0
June 23	McCormick Woods Brookfield, IL	0.3 ± 0.1	0.22 ± 0.02	1
June 23	Bemis Woods Hinsdale, IL	0.4 ± 0.1	0.18 ± 0.01	1
October 12	St. Joseph, MI	0.4 ± 0.1	0.20 ± 0.02	0
October 13	Willow Springs, IL	0.5 ± 0.2	-	1
October 14	Dresden Lock & Dam, IL	0.4 ± 0.1	0.45 ± 0.03	1
	Average	0.4 ± 0.1	0.24 ± 0.14	1

These results are transcribed from "Environmental Monitoring at Argonne National Laboratory Annual Report for 1976" (ANL-77-13) by N. W. Golchert, T. L. Duffin, and J. Sedlet. These measurements are presented in Table 13, on page 47 of the

INSTRUMENTATION

Below are the conversion factors used to obtain the readings in disintegrations per minute per 100cm² (dpm/100cm²).

I Conversion Factors

	<u>Floor Monitor (FM-4G)</u>	<u>PAC-4G-3</u>
To 100cm ²	0.31	1.6
cpm to dpm (alpha)	2	2
cpm to dpm (beta)	2	2
cpm to dpm (K ⁴⁰)	-	16.5

II Derivation of Conversion FactorsFloor Monitor (FM-4G)

Window Area: ~325cm²

Conversion to 100cm² = .31 times floor monitoring reading

PAC-4G-3

Window Area: ~61cm²

Conversion to 100cm² = 1.6 times PAC reading

2 π Internal Gas Flow Counter, PC-3A

Geometry: Mylar Spun Top - 0.43

Mylar Spun Top Counting (window double aluminized m. mg/cm²) utilizes the well of the PC-3A and is a method used by the Argonne National Laboratory Health Section for negating the dielectric effect in counting on non-conducting media.

The conversion factors for $\text{cpm}/100\text{cm}^2$ to $\text{dpm}/100\text{cm}^2$ are given below.

I CONVERSION EQUATION (ALPHA)

$$\frac{\text{cpm} - \text{Bkgd}}{\text{g} \times \text{bf} \times \text{sa} \times \text{waf}} = \text{dpm Alpha}$$

geometry (g) of 0.43 is standard for all flat plate counting.

backscatter factor (bf) of 1.0 is used when determining alpha activity on filter media.

self-absorption (sa) was assumed to be 1 unless otherwise determined.

If the energies of the isotope were known, the appropriate window air factor (waf) was used; if the energies of the isotopes were unknown the waf of ^{238}Pu which is .713, was used.

II CONVERSION EQUATION (BETA)

$$\frac{\text{cpm} - (\text{Beta Bkgd} + \text{Alpha cpm})}{\text{g} \times \text{bf} \times \text{sa} \times \text{waf}} = \text{dpm Beta}$$

geometry (g) of 0.43 is standard for all flat plate counting.

backscatter factor (bf) of 1.1 is used when determining beta activity on filter media.

self-absorption (sa) was assumed to be 1 unless otherwise determined.

If the energies of the isotopes were known, the appropriate window air factor (waf) was used; if the energies of the isotopes were unknown, the waf of $\text{Sr-}^{90}\text{Y}$, which is 0.85 was used.

This attachment summarizes the air sampling calculations for samples collected using Argonne National Laboratory designed air sampler with HV-70 filter media. The attachment includes the basic assumptions and calculations used to derive the air concentrations.

Radon Concentrations Based on RaC' Results

The following postulates are assumed in deriving the Radon-222 (^{222}Rn) concentrations as based on the RaC' alpha count results.

1. RaA, RaB, RaC, RaC', are in equilibrium.
2. RaA is evident only in the first count and not the 100 minute decay count.
3. That one-half of the Radon progeny is not adhered to airborne particulate, and therefore, not evident on the filter media.
4. The geometry factor (g) is 0.43 for both the alpha and beta activity.
5. The backscatter factor (bf) of 1.0 is used for the alpha activity which is determined from RaC'.
6. The sample absorption factor (sa) for RaC' is 0.77.
7. The window air factor (waf) for RaC' is 0.8.
8. RaB and RaC being beta emitters, are not counted in the alpha mode.
9. The half-life of the Radon progeny is approximately 36 minutes, based on the combined RaB and RaC half-lives.
10. No long-lived alpha emitters present as evidenced by the final recount.
11. For all practical purposes, RaC' decays at the rate of the composite of RaB and RaC which is approximately 36 minutes.

II. Equations Used to Derive Air Concentrations

$$N_o = \frac{N}{e^{-\lambda t}}$$

Where: N_o = Activity present at the end of the sampling period

N = Activity at some time interval, after end of sampling period

t = Time interval N_o to N

$$\lambda = \frac{.693}{t_{1/2}}$$

$t_{1/2}$ = Half-life of isotope

$$C = \frac{A \lambda}{f} \frac{1}{(1 - e^{-\lambda t})}$$

Where: C = Concentration per unit volume

A = Activity of filter media at end of sampling period
(N_o from previous equation)

f = Sampling rate (M^3/minute)

t = Time sampling was taken

$$\lambda = \frac{.693}{t_{1/2}}$$

$t_{1/2}$ = Half life of isotope or controlling parent

I. Example Calculations - Room E-15

$$N_o = \frac{498 \text{ dpm}}{e^{-\frac{.693 \times 104}{36}}} = 3687 \text{ dpm}$$

$$C = \frac{3687 \times \frac{.693}{36}}{15/60} \frac{1}{1 - e^{-\frac{.693 \times 40}{36}}} = 529 \text{ dpm/M}^3 \times 2 = 1057 \text{ dpm/M}^3$$

TIME OF COLLECTION: 1242

SUSPECTED ISOTOPE: Unidentified

LENGTH OF RUN: TIME STOPPED 1322 MINUS TIME STARTED 1242 TOTAL TIME 40 MINUTES

VOLUME: COLLECTION RATE 15 M³/hr X TOTAL TIME 40 MINUTES = VOLUME 10 M³

60

DATE AND TIME OF COUNT	GROSS COUNTS			BKGD	NET	GEOMETRY	SAMPLE ABSORPTION	WINDOW AIR FACTOR	DISINTEGRATIONS PER MINUTE *	d/m/M ³	TYPE OF ACTIVITY	DECAY TIME	
	COUNTS / MIN.												
	COUNTS / MIN.												
	TOTAL COUNTS	COUNT TIME MIN.	COUNTS / MIN.										
1324	118	2	59	0.03	59	.43	1	.77	.8	2226	223	α	2 min.
1502	74	2	37	0.03	37	.43	1	.77	.8	1396	140	α	100 min.
1300	0	2	0	0.5	BKGD.	.43	1	.77	.8	BKGD.	BKGD.	α	6 days
1326	2114	2	1057	47.3 + 59	590.7	.43	1.1	1	.95	21,174	2117	β	4 min.
1504	634	2	317	47.3 + 37	232.7	.43	1.1	1	.95	5182.6	518	β	102 min.
1300	80	2	40	53.3	BKGD.	.43	1.1	1	.95	BKGD.	BKGD.	β	6 days

HA:

cpm - Bkdg = dpm Alpha

BETA: Pure Beta emitters
cpm - Bkdg = dpm Beta

COMPOSITE: Beta determination
cpm - Beta Bkdg + Alpha cpm = dpm Beta

AIR SAMPLE DATA

LOCATION: MUSEUM OF SCIENCE AND INDUSTRY E-14

SAMPLE COLLECTION DATE: 2/1/77

TIME OF COLLECTION: 1046

SUSPECTED ISOTOPE: Unidentified

LENGTH OF RUN: TIME STOPPED 1126 MINUS TIME STARTED 1046 TOTAL TIME 40 MINUTES

VOLUME: COLLECTION RATE 15 M³/hr X TOTAL TIME 40 MINUTES = VOLUME 40 M³

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DATE AND TIME OF COUNT	GROSS COUNTS				BKGD	NET	GEOMETRY						TYPE OF A			
	TOTAL COUNTS		COUNT TIME MIN.				COUNTS / MIN.		COUNTS / MIN.		BACKSCATTER FACTOR	SAMPLE ABSORPTION		WINDOW AIR FACTOR	DISTINTEGRATIONS PER MINUTE *	d/m/M ³
			COUNTS	MIN.			COUNTS	MIN.								
2/1 1135	176	2	88	0.3	87.7	.43	1	.77	.8	3311	331	α	9			
2/1 1315	27	2	13.5	0.3	13.2	.43	1	.77	.8	498	50	α	10			
4/21 1300	0	2	0	0.5	BKGD	.43	1	.77	.8	BKGD	BKGD	α	79			
2/1 1133	909	2	455	91.6 + 88.	275.4	.43	1.1	1	.95	6133	613	β	7			
2/1 1313	384	2	192	91.6 + 13.5	85.9	.43	1.1	1	.95	1935	4	β	10			
4/21 1300	68	2	34	53.5	BKGD	.43	1	1	.95	BKGD	BKGD	α	7			

INSTITUTION: MUSEUM OF SCIENCE AND INDUSTRY										TIME OF COLLECTION: 1149		SUSPECTED ISOTOPE: Unidentified							
DATE OF RUN: TIME STOPPED 1229 MINUS TIME STARTED 1149										TOTAL TIME 40		MINUTES							
VOLUME: COLLECTION RATE 15 M ³ /hr X TOTAL TIME 40 MINUTES = VOLUME 10 M ³																			
60																			
DATE AND TIME OF COUNT	GROSS COUNTS			BKGD	NET	GEOMETRY	BACKSCATTER FACTOR	SAMPLE ABSORPTION	WINDOW AIR FACTOR	DISINTEGRATIONS PER MINUTE *	d/m/M ³	TYPE OF ACTIVITY	DECAY TIME						
	TOTAL COUNTS	COUNT TIME MIN.	COUNTS / MIN.	COUNTS / MIN.	COUNTS / MIN.														
1233	179	2	89.5	0.3	89.2	.43	1	.77	.8	3366	337	α	4 min						
1413	27	2	13.5	0.3	13.2	.43	1	.77	.8	498	50	α	104 min						
1300	1	2	0.5	0.5	BKGD	.43	1	.77	.8	BKGD	BKGD	α	79 days						
1235	929	2	462	91.6 + 89.5	280.9	.43	1.1	1	.95	6256	626	β	6 min						
1415	291	2	145.5	91.6 + 13.5	40.4	.43	1.1	1	.95	899	90	β	106 min						
	87	2	43.5	54.0	BKGD	.43	1.1	1	.95	BKGD	BKGD	β	79 days						
LPHA: cpm - Bkdg = dpm Alpha										BETA: Pure Beta emitters cpm - Bkdg = dpm Beta									
										COMPOSITE: Beta determination cpm - Beta Bkdg + Alpha cpm = dpm Beta									
										g x bf x sa x waf									

AIR SAMPLE DATA

ATION: MUSEUM OF SCIENCE AND INDUSTRY E-18

SAMPLE COLLECTION DATE: 2/16/77

TIME OF COLLECTION: 1100

SUSPECTED ISOTOPE: Unidentified

NGTH OF RUN: TIME STOPPED 1140 MINUS TIME STARTED 1100 TOTAL TIME 40 MINUTES

OLUME: COLLECTION RATE 15 M³/hr X TOTAL TIME 40 MINUTES = VOLUME 10 M³

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DATE AND TIME OF COUNT	GROSS COUNTS				BKGD	NET	GEOMETRY	BACKSCATTER FACTOR	SAMPLE ABSORPTION	WINDOW AIR FACTOR	DISINTEGRATIONS PER MINUTE *	d/m/M ³	TYPE OF ACTIVITY	DECAY TIME
	TOTAL COUNTS	COUNT TIME MIN.	COUNTS / MIN.	COUNTS / MIN.										
1150	292	2	146	0.5	145.5	.43	1	.77	.8	5490	549	α	10 min	
1330	76	2	38	0.5	37.5	.43	1	.77	.8	1415	145	α	110 min	
1300	0	2	0	0.5	BKGD	.43	1	.77	.8	BKGD	BKGD	α	64 days	
1152	1599	2	799	⁸⁷ + 146	566	.43	1.1	1	.95	12605	1261	β	12 min	
1332	466	2	233	⁸⁷ + 38	108	.43	1.1	1	.95	2405	241	β	142 min	
1300	99	2	43.5	53.5	BKGD	.43	1.1	1	.95	BKGD	BKGD	β	64days	

At:

BETA: Pure Beta emitters

COMPOSITE: Beta determination

TIME OF COLLECTION: 1030

SUSPECTED ISOTOPE:

LENGTH OF RUN: TIME STOPPED 1110 MINUS TIME STARTED 1030 TOTAL TIME 40 MINUTES

VOLUME: COLLECTION RATE 15 M³/hr X TOTAL TIME 40 MINUTES = VOLUME 10 M³

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DATE AND TIME OF COUNT	GROSS COUNTS				BKGD	NET	GEOMETRY	BACKSCATTER FACTOR	SAMPLE ABSORPTION	WINDOW AIR FACTOR	DISINTEGRATIONS PER MINUTE *	d/m/M ³	TYPE OF ACTIVITY	DECAY TIME
	COUNT TIME MIN.													
	COUNTS / MIN.													
	COUNTS / MIN.													
	TOTAL COUNTS													
1119	1555	2	77.5	0.3	77.2	.43	1	.77	.8	2913	291	α	9 min	
1259	25	2	12.5	0.3	12.2	.43	1	.77	.8	460	46	α	109 min	
1300	0	2	0	0.5	BKGD	.43	1	.77	.8	BKGD	BKGD	α	50 days	
1117	853	2	426.5	83 + 77.5	266	.43	1.1	1	.95	5924	592	β	7 min	
1257	284	2	142	83 + 12.5	46.5	.43	1.1	1	.95	1035	4	β	107 min	
1300	64	2	32	53.5	BKGD	.43	1.1	1	.95	BKGD	BKGD	β	50 days	

PHA:

cpm - Bkdg

BETA: Pure Beta emitters
cpm - Bkdg

COMPOSITE: Beta determination

cpm - Beta Bkdg + Alpha cpm

E-117 South

SAMPLE COLLECTION DATE: 3/1/77

TIME OF COLLECTION: 1026

SUSPECTED ISOTOPE: Unidentified

LENGTH OF RUN:	TIME STOPPED	MINUS	TIME STARTED	TOTAL TIME	MINUTES
	1106		1026	40	

TIME:	COLLECTION RATE	15	M ³ /hr	TOTAL TIME	40	MINUTES	- YOU TIME
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E AND TIME OF COUNT	GROSS COUNTS				BKGD	NET	GEOMETRY			SAMPLE ABSORPTION	WINDOW AIR FACTOR	DISINTEGRATIONS PER MINUTE *	d/m/M ³	TYPE OF ACTIVITY	DECAY TIME
	COUNT TIME MIN.		COUNTS / MIN.				COUNTS / MIN.	COUNTS / MIN.	COUNTS / MIN.						
	TOTAL COUNTS	COUNT TIME MIN.	COUNTS / MIN.	COUNTS / MIN.											
	1111	149	2	74.5	0.5	74.0	.43	1	.77	.8	2792	279	α	5 min	
1251	59	2	19.7	0.5	19.2	.43	1	.77	.8	724	72	α	105 min		
1300	0	2	0	0.5	BKGD	.43	1	.77	.8	BKGD	BKGD	α	51 days		
1113	835	2	417.5	⁷⁹ +74.5	264	.43	1.1	1	.95	5879	588	β	7 min		
1253	426	2	142	⁷⁹ +19.7	43.3	.43	1.1	1	.95	964	96	β	107 min		
1300	42	2	21	53.5	BKGD	.43	1.1	1	.95	BKGD	BKGD	β	51 days		

TIME OF COLLECTION: 1100

SUSPECTED ISOTOPE: Unidentified

LENGTH OF RUN: TIME STOPPED 1142 MINUS TIME STARTED 1100 TOTAL TIME 42 MINUTES

TIME: COLLECTION RATE 15 M³/hr X TOTAL TIME 42 MINUTES = VOLUME 10.5 M³

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COUNT	DATE AND TIME OF												
	GROSS COUNTS			BKGD	NET	GEOMETRY	BACKSCATTER FACTOR	SAMPLE ABSORPTION	WINDOW AIR FACTOR	DISINTEGRATIONS PER MINUTE *	d/m/M ³	TYPE OF ACTIVITY	DECAY TIME
	TOTAL COUNTS	COUNTS / MIN.		COUNTS / MIN.	COUNTS / MIN.								
		COUNT TIME MIN.	COUNTS / MIN.										
1149	312	2	156	0.2	155.8	.43	1	.77	.8	5879	560	α	7 min
1338	47	2	23.5	0.2	23.3	.43	1	.77	.8	879	84	α	116 min
1300	0	2	0	0.5	BKGD	.43	1	.77	.8	BKGD	BKGD	α	36 days
1151	1526	2	762	57.8 + 156	549.2	.43	1.1	1	.95	12231	1165	β	9 min
1340	337	2	168.5	57.8 + 23.5	87.2	.43	1.1	1	.95	1942	185	β	118 min
1300	42	2	21	53.5	BKGD	.43	1.1	1	.95	BKGD	BKGD	β	36 days

BETA: Pure Beta emitters

COMPOSITE: Beta determination

CPH: cpm - Bkdg = dpm Alpha

cpm - Bkdg = dpm Beta

cpm - Beta Bkdg + Alpha cpm = dpm Beta

e x bf x sa x waf